A Global Approach to Soot Cleaning Optimization at Dynegy's Baldwin Energy Complex

Presented by:

Randy Short – Dynegy, Baldwin Energy Complex

Rob James – NeuCo

EPRI Heat Rate Improvement Conference

January 25, 2007

DYNEGY

Agenda

- Baldwin Energy Complex Overview
- Motivations for Optimization
- Soot Cleaning Optimization
- Looking Ahead

DYNEGY

Dynegy's Baldwin Energy Complex

3 - 600 MW Units

1970-1975

Units 1 & 2 Cyclone Fired

14 Cyclones/Unit

Unit 3 Tangential-Fired

6 Mills

PRB Coal

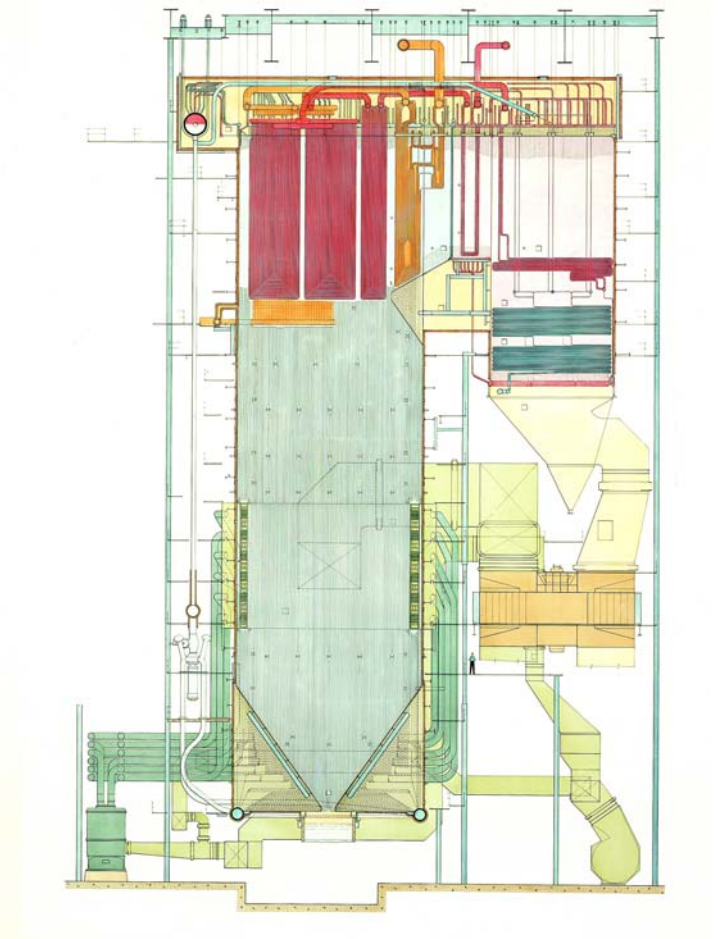
Conversions

1999 & 2000

DYNEGY

Baldwin Unit 3

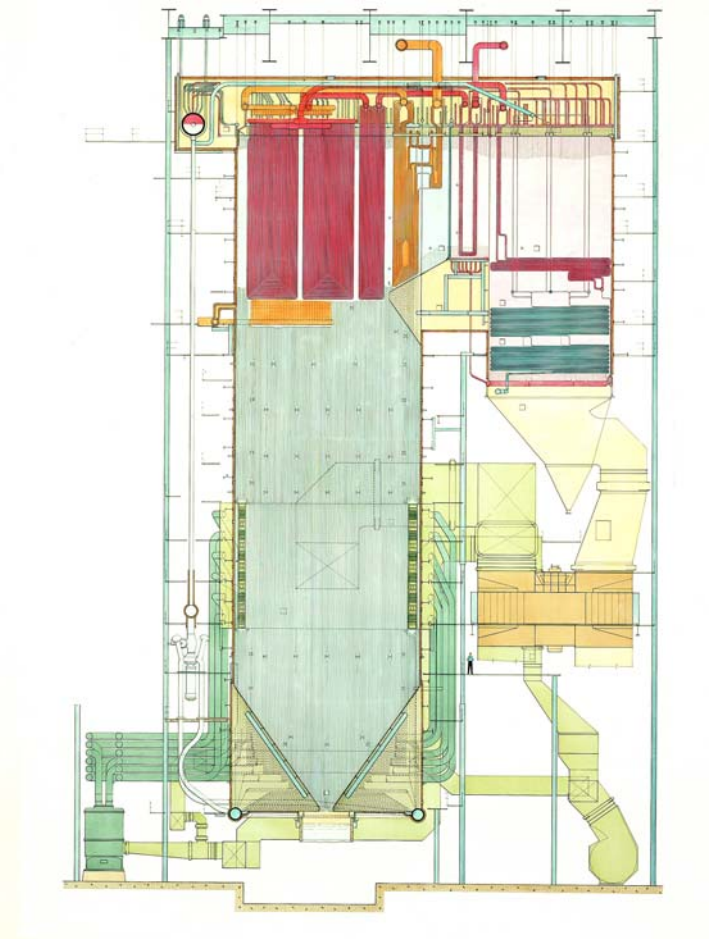
- CE Drum-type Boiler
- Pulverized T-Fired: Six Pulverizers
- Furnace Dimensions: 52’ x 58’, 180’ tall
- SOFA, Low NOx Burners
- Steam Conditions
  - Flow: 4.2 MLb/Hr
  - SH/ RH Temperature: 1005F/1005F
  - Throttle Pressure: 2425 Psig



DYNEGY

Baldwin 3 – Ash Deposition

- PRB Coal
  - Intermittent Wall Deposition
  - Division Panels
  - SH Pendant
  - Horizontal SH



DYNEGY

Unit 3 Sootblowing Operation prior to 2006

- High variability in PRB coal
- Water Cannons and Heat Flux Sensors in Furnace area
- PrecisionClean and standard IK's in convection pass
- ASI control system to operate water cannons & sootblowers
- Prevailing sootblowing guidelines:
  - Water cannons operator initiated when attemperation spray flows high
  - Operator initiated sequences in the convection pass – normally a sequence of most IK's running continuously
  - Monitor furnace-to-economizer and furnace-to-reheater differential pressures; Increase sootblowing if differentials increase

DYNEGY

Motivations for Optimization

- Full Load PRB operation requires tight control
  - Loss of spare mill at full capacity
  - Small process changes have significant effects
  - Seasonal impacts to heat rate

- Expectations
  - Ability to control key parameters on consistent basis
  - Ability to compensate for changes in coal quality
  - Improved understanding of available data and its use for improved operations
  - Ability to optimize controls to meet plant objectives

DYNEGY

Why Optimize Soot Cleaning?

- Cleaning actions (or lack thereof) affect many plant parameters:
  - Slagging/fouling impacts heat transferability
  - Capacity: Steam and gas temperatures, spray flows, differential pressures, fan limits
  - Performance: Boiler efficiency, heat rate
  - Emissions: NOx, Opacity, LOI, CO
  - Availability/Reliability: Waterwall/tube longevity, EFOR, equipment wear-and-tear

DYNEGY

What SootOpt Does

- Optimizes boiler cleaning based on unit-specific objectives:
  - Improves Heat Rate including Reheat & Superheat steam temperature control
  - Improves emissions control (NOx, opacity, CO)
  - Balances tradeoffs between furnace/backpass absorption
  - Reduces O&M costs by avoiding unnecessary boiler cleaning actions and reducing tube wear and thermal stressing
  - Compensates for off-design fuels and operations
  - Leverages existing soot cleaning instrumentation, models, equipment and control systems

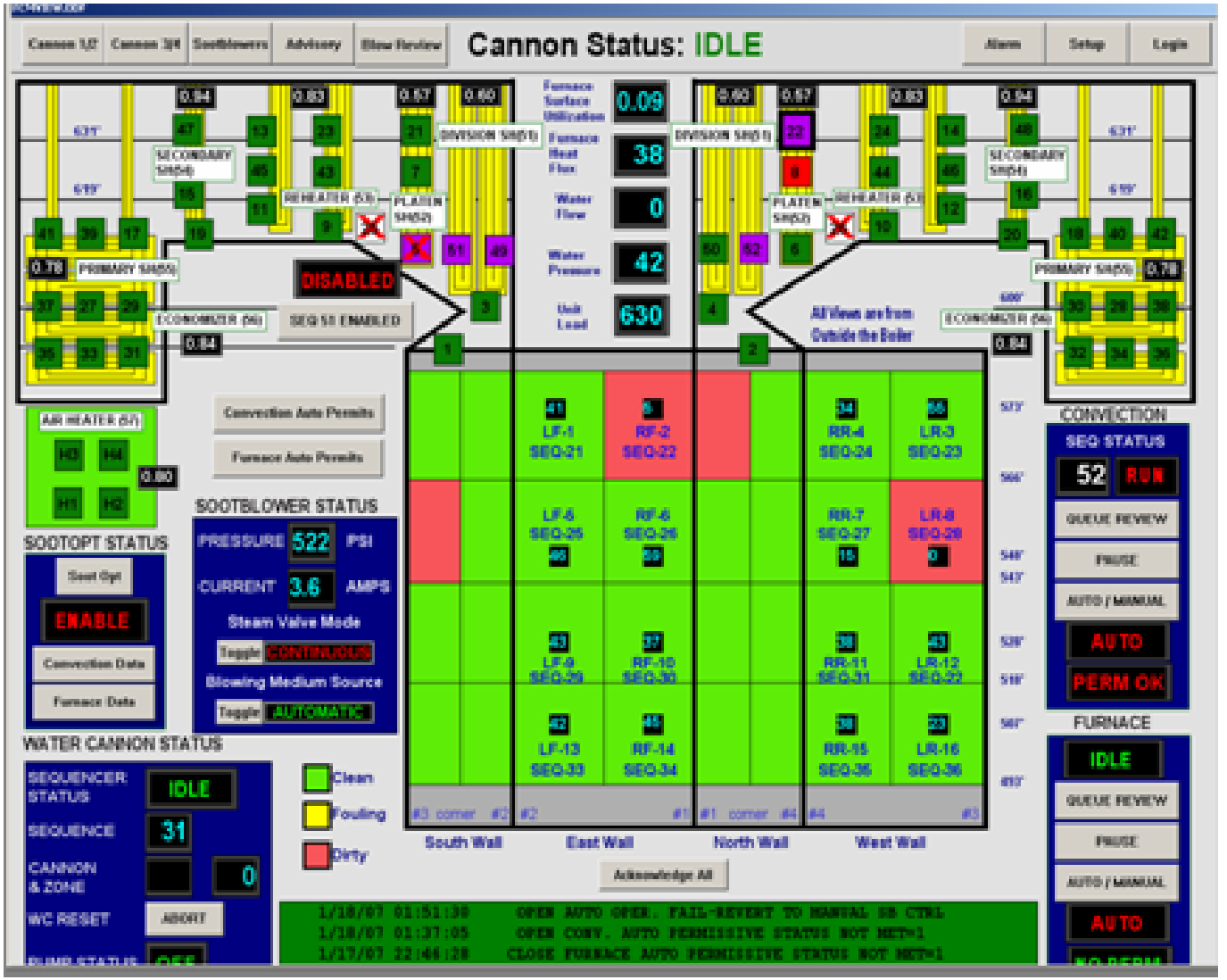
DYNEGY

ISB & SootOpt installed in 2006 on Unit 3

- Upgraded sootblowing controls to Diamond SentrySeries 1500 Intelligent Sootblowing Control System (ISB)
- Added thermocouples and thermoprobe behind pendent reheater for heat transfer calculations
- Installed NeuCo's SootOpt for adaptive optimization of sootblowing operation (NeuCo's CombustionOpt neural optimizer already in operation for furnace combustion)

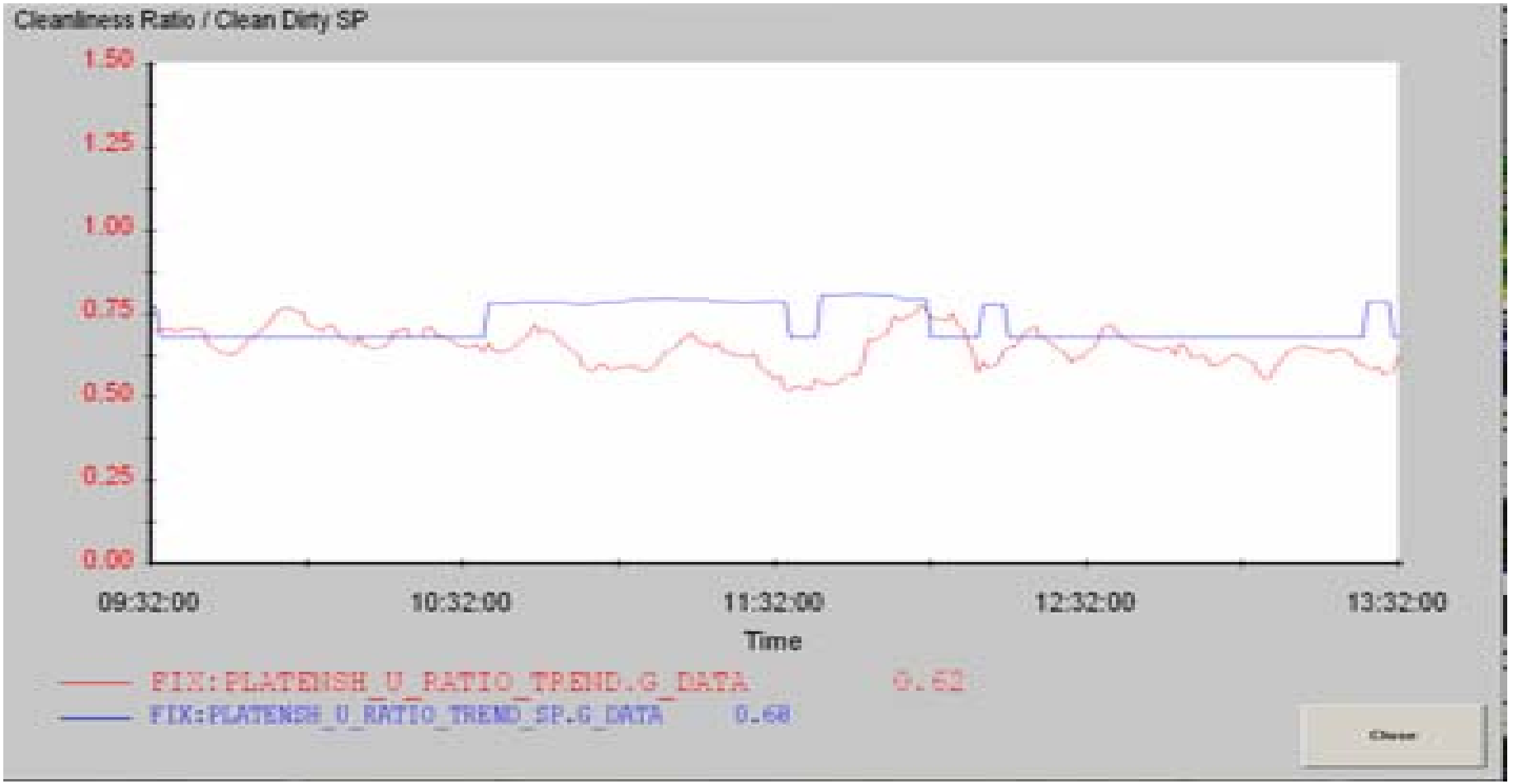
DYNEGY

Diamond Intelligent Sootblowing System



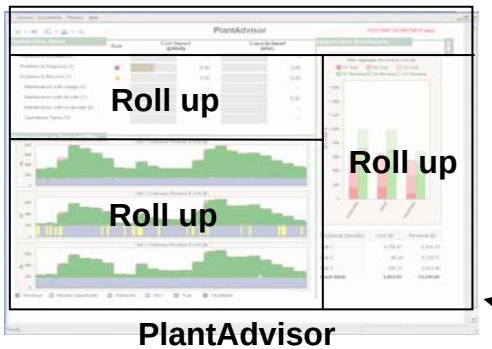
DYNEGY

How SootOpt Interfaces with ISB

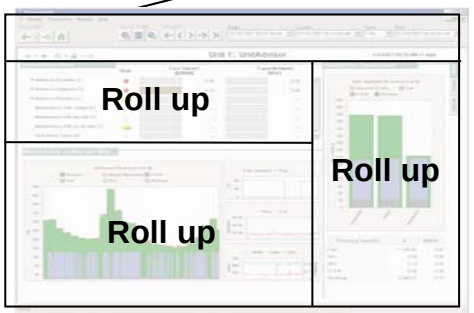


DYNEGY

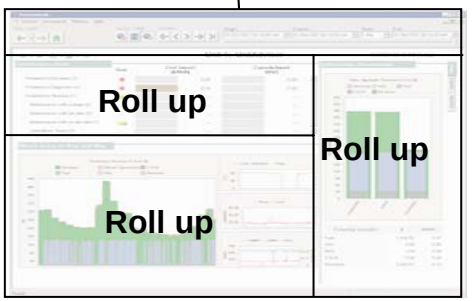
ProcessLink Platform: Enterprise Architecture



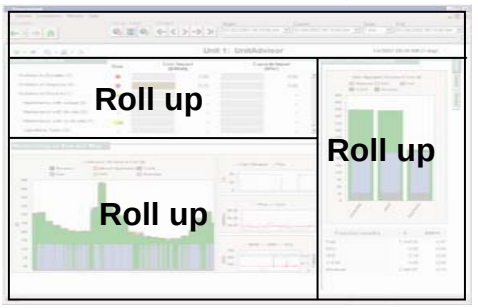
PlantAdvisor



Unit 1 UnitAdvisor

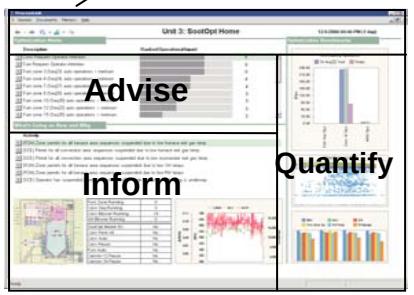


Unit 2 UnitAdvisor



Unit 3 UnitAdvisor

CombustionOpt



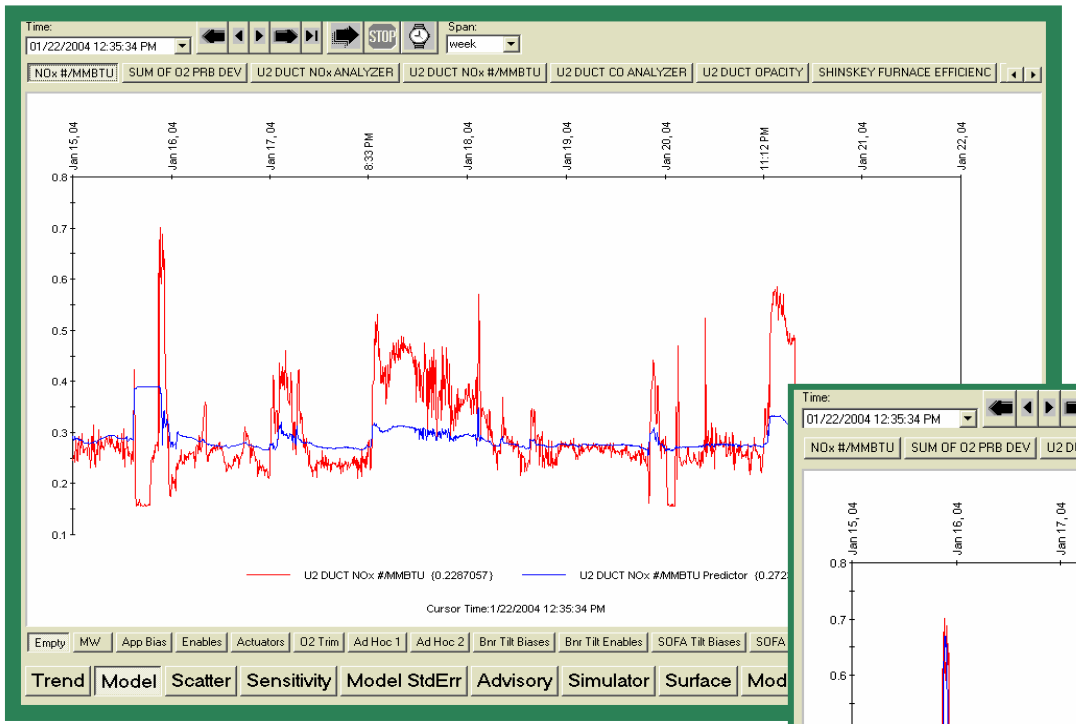
SootOpt

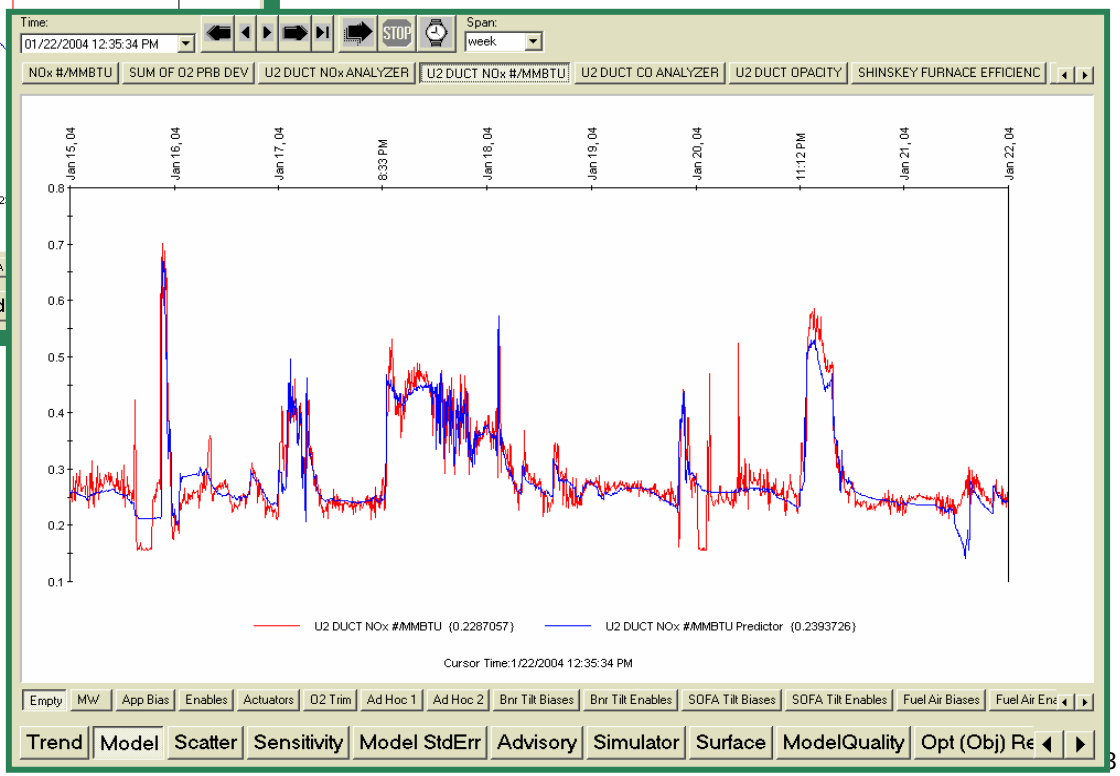
PerformanceOpt

MaintenanceOpt

DYNEGY

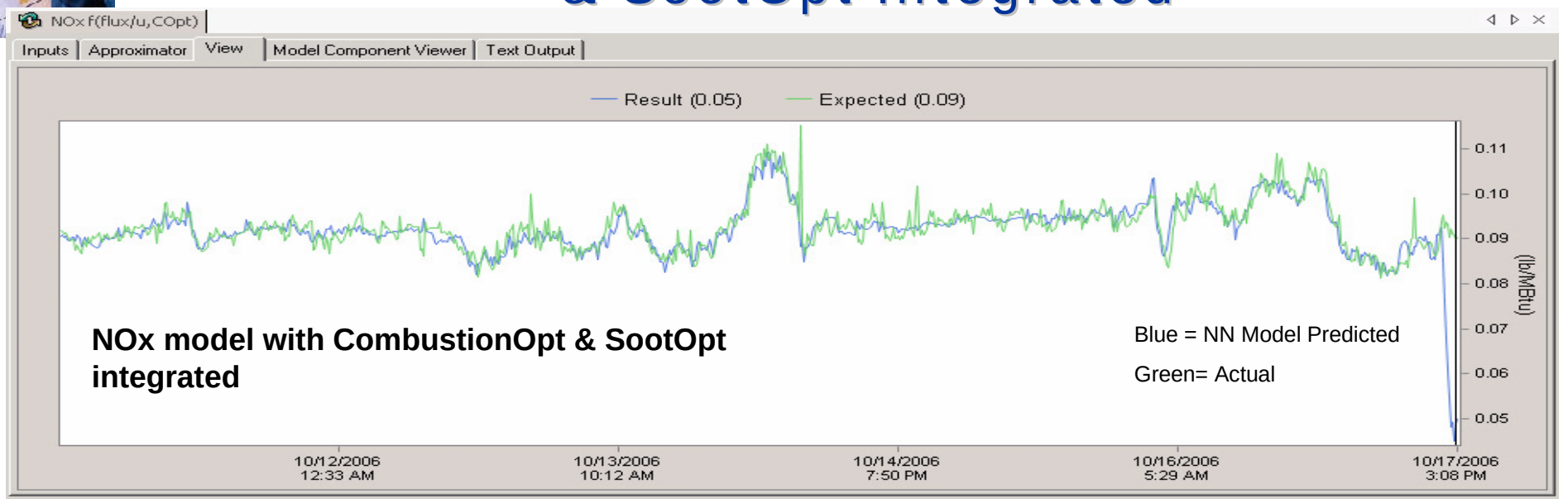
Models Learn from Data



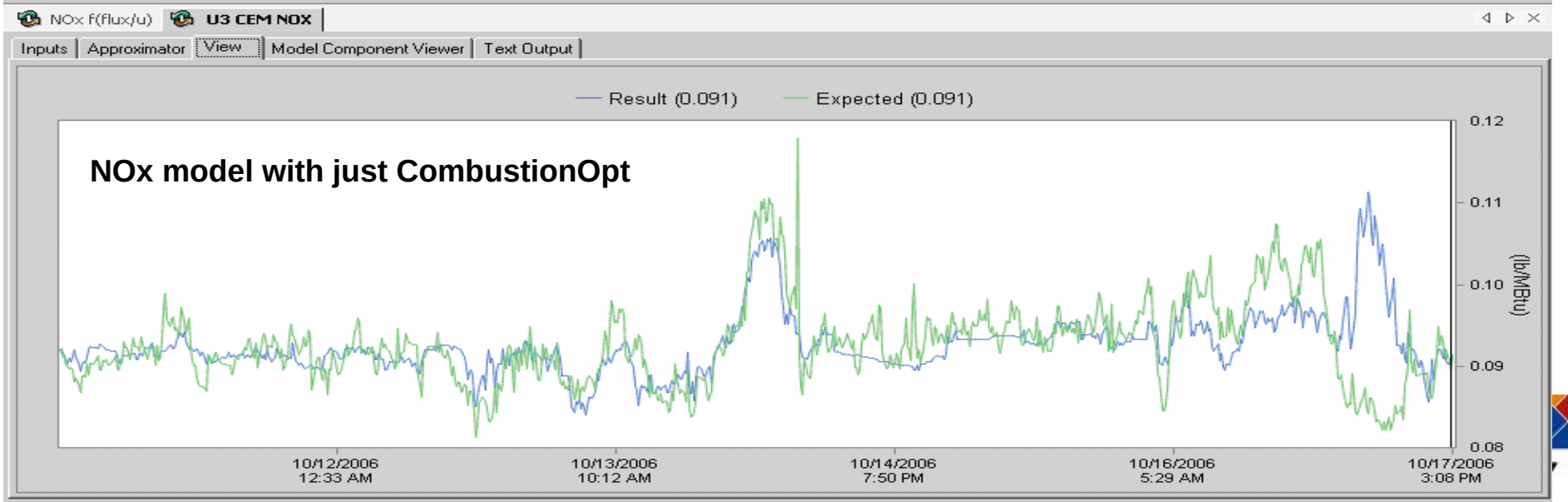


Model NOx Predictions (blue) vs. actual Measured NOx (red) before and after sustained training on plant data.

Improved Model Fidelity with CombustionOpt & SootOpt Integrated



Improved Model Fidelity with CombustionOpt & SootOpt Integrated



ProcessLink - [SootOpt Homepage - complete (ProcessLink.Applications.Documents.Forms.Form viewer)]

Session Documents Memory Help

Unit 3: SootOpt Home

1/24/2007 08:51:00 AM (1 day)

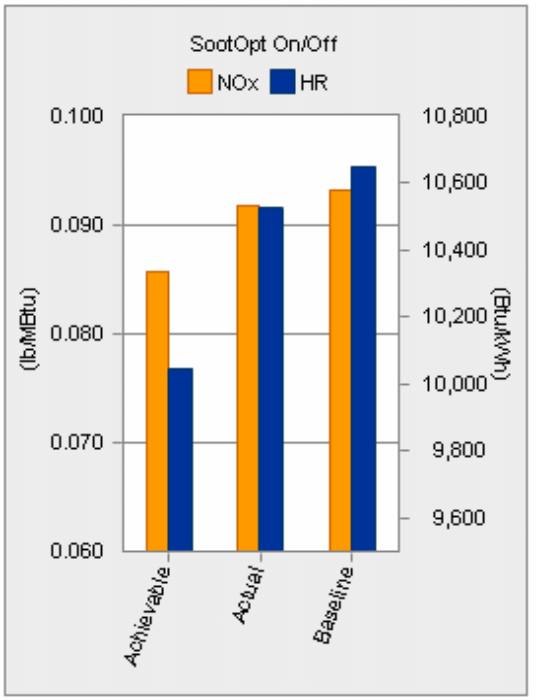
Optimization Advice

Description	Ranked Operational Impact
Convection area no permit or not in auto	0.80
Some Econ IKs below min required ops	0.60
Some PlatSH IKs below min required ops	0.60
Some RH IKs below min required ops	0.60
Furn zone 2 (Seq22) auto operations < minimum	0.40
Furn zone 10 (Seq30) auto operations < minimum	0.40

What's Going on Now and Why

Activity
(FCM) Zone permits for all furnace area sequences suspended due to low furnace exit gas temp
(SCE) Permit for all convection area sequences suspended due to low furnace exit gas temp
(SCE) Operator has suspended permit for DivSH(Seq51) while bottom ash cleaning is underway

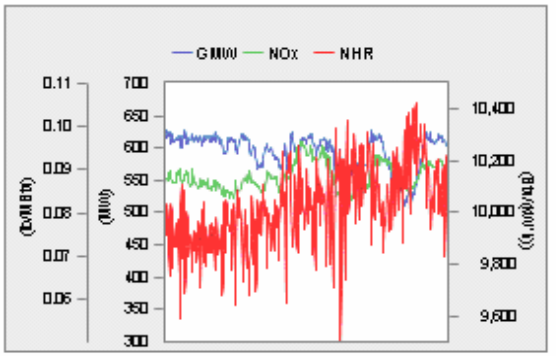
Optimization Benchmarks

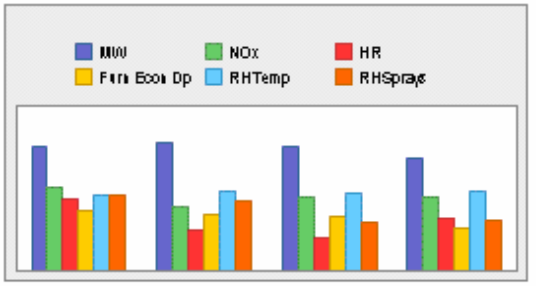


	Benefit	Missed
HR (Btu/kWh)	119	488
NOx (lb/MBtu)	0.0015	0.0061

Furn Zone Running	0
Conv Seq Running	56 (Econ)
Conv Blower Running	0
AH Blower Running	0

SootOpt Master En	Yes
Conv Perm All	No
Conv Auto	Yes
Conv Pause	No
Furn Auto	Yes
Cannon 12 Pause	No
Cannon 34 Pause	No





Ready

ProcessLink

Session Documents Memory Help

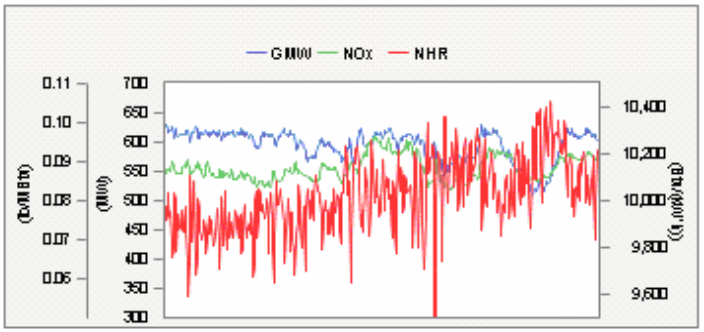
Unit 3: SootOpt Analysis

7 days | 01/24/2007 08:51:00 AM

Standard | ON/OFF | Demystifier | Trend | Model | Scatter | Surface | Sensitivity | Std Error | Custom

Activity/Status | Zone States | Boiler Map

Gross MW	603.39 MW
Net MW	577.28 MW
Opacity	15.35 %
Furnace to RH dP	0.35 inH2O
Furnace to Econ dP	5.42 inH2O
SH Temp	1,007.94 degF
RH Temp North	1,001.56 degF
RH Temp South	1,004.62 degF
SH Spray Flow	105.23 klb/h
RH Spray Flow	33.2 klb/h
Avg Furn Flux	38.15 f



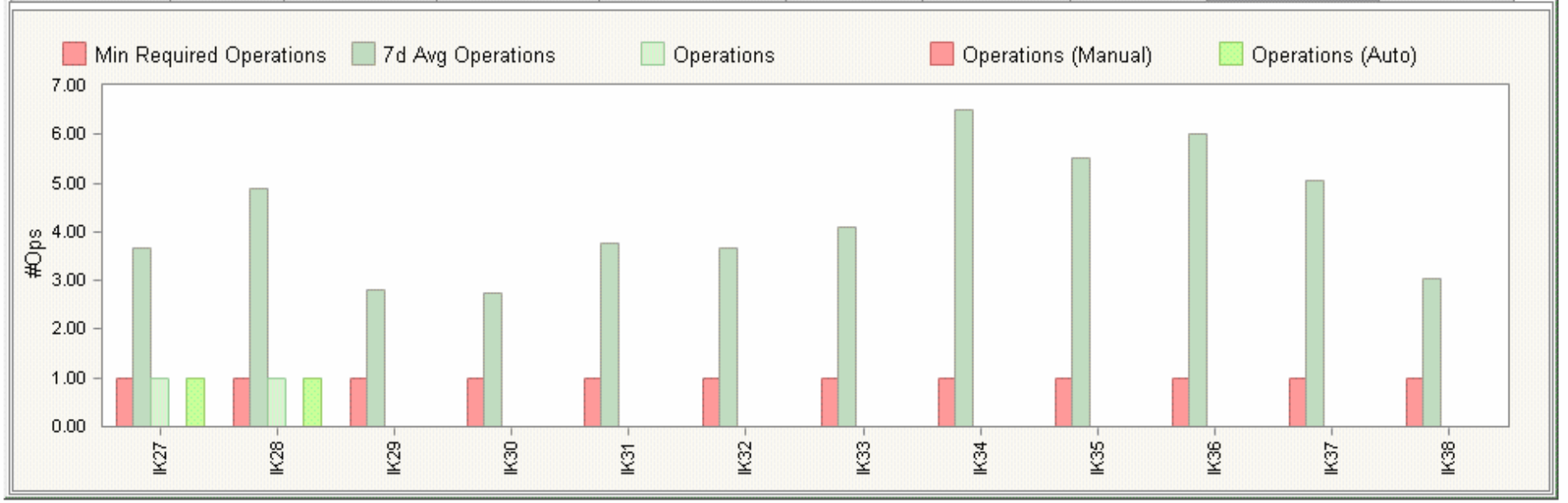
	7dAvg	Yest	Today
Seq Ops	73.01	59	21
Conv/AH Seq Ops	38.17	33	9
Furn Seq Ops	22.29	12	6
Conv IK Ops	163.91	89	40
AHIKOps	7.25	8	4

Furn Zone Running	0
Conv Seq Running	56 (Econ)
Conv Blower Running	0
AH Blower Running	0

SootOpt Master En	Yes
Conv Perm All	No
Conv Auto	Yes
Conv Pause	No
Furn Auto	Yes
Cannon 12 Pause	No
Cannon 34 Pause	No

IK Operations | Sequence Operations | Convection Details | Furnace Details

Zone Status | IK Status | Nose (Seq58) | DivSH (Seq51) | PlatenSH (Seq52) | RH (Seq53) | SSH (Seq54) | PriSH (Seq55) | Econ (Seq56) | AH (Seq57)



Ready

ProcessLink

Session Documents Memory Help

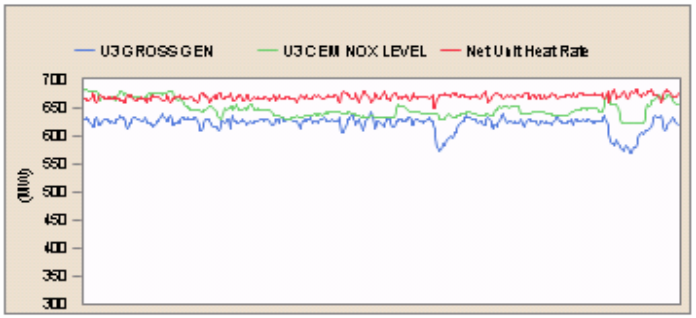
Unit 3: SootOpt Analysis

1 day | 11/04/2006 05:11:05 PM

Standard | Demystifier | Trend | Model | Scatter | Surface | Sensitivity | Std Error | Custom

Activity/Status | Zone States | Boiler Map

Gross MW	620.12 MW
Net MW	592.35 MW
Opacity	16.46 %
Furnace to RH dP	0.41 inH2O
Furnace to Econ dP	6.2 inH2O
SH Temp	966.88 degF
RH Temp North	956.66 degF
RH Temp South	972.48 degF
SH Spray Flow	30 klb/h
RH Spray Flow	0 klb/h
Avg Furn Flux	40.65 f

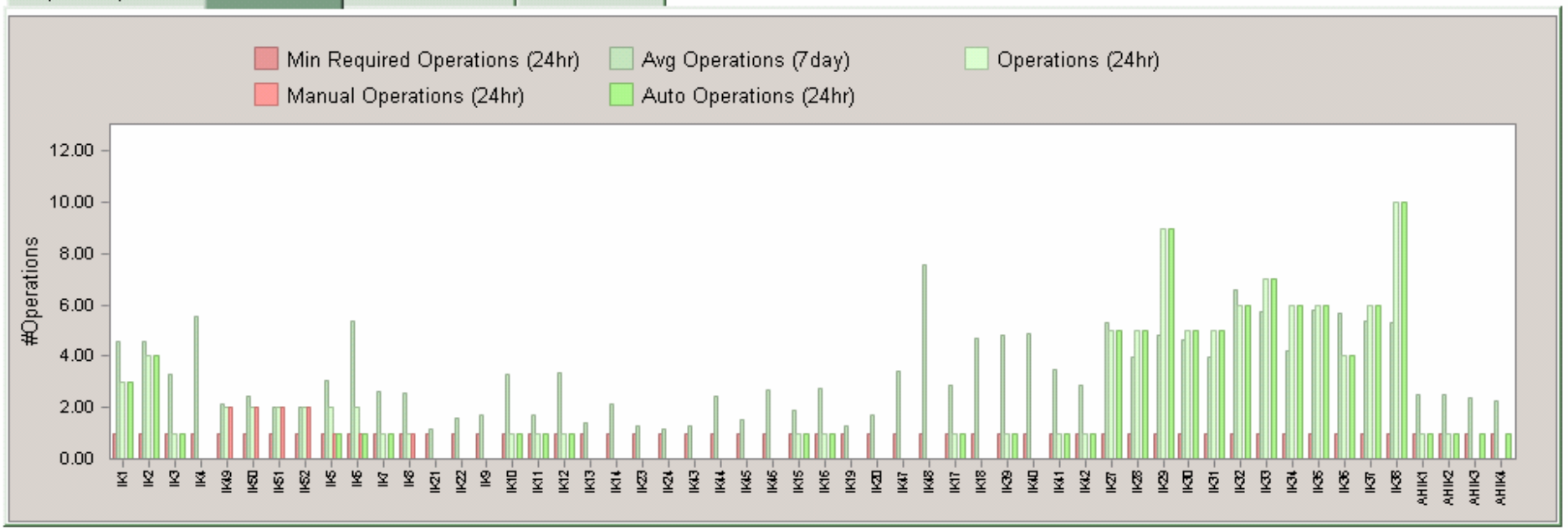


	7dAvg	Yest	Today
Seq Ops	93.96	56	43
Conv/AH Seq Ops	39.55	16	16
Furn Seq Ops	41.49	29	18
Conv IK Ops	170.54	131	83
AHIKOps	9.24	8	6

Furn Zone Running	5
Conv Seq Running	0
Conv Blower Running	0
AH Blower Running	0

SootOpt Master En	Yes
Conv Perm All	Yes
Conv Auto	Yes
Conv Pause	No
Furn Auto	Yes
Cannon 12 Pause	No
Cannon 34 Pause	No

Sequence Operations | IK Operations | Convection Details | Furnace Details



Ready

Visibility into Heuristics

ProcessLink

Session Documents Memory Help

Unit 3: SootOpt Analysis

1 day

Standard | Demystifier | Trend | Model | Scatter | Surface | Sensitivity | Std Error | Custom

	Sys	Enabled	Active	Min	Actual	Max	Unit
Pause all convection sequences, FEGT violation	SCE	Yes	No	1,900	1,993.1		degF
Pause all convection sequences, load violation	SCE	Yes	No	400	633.8		MW
Pause all convection sequences, EEGT violation	SCE	Yes	No	600	693		degF
Pause all convection sequences, tilts violation	SCE	Yes	No		-0.3	5	%
Pause RH(53), RH spray violation	SCE	Yes	No		23.6	75	klb/h
Pause DivSH(51) and PlatSH(52), RH temp violation	SCE	Yes	No	975	995		degF
Pause Nose(58), RH(53) SH outlet temp violation	SCE	Yes	No	990	990.2		degF
Pause all convection sequences but DivSH(51), DivSH running	SCE	Yes	Yes				
Operator has inhibited DivSH(51)	SCE	Yes	No				
Pause all furnace sequences, tilts violation	FCM	Yes	No		-0.3	5	%
Pause all furnace sequences, FEGT violation	FCM	Yes	No	1,900	1,993.1		degF
Pause all furnace sequences, load range violation	FCM	Yes	No	400	633.8		MW
Pause all furnace sequences, SH outlet temp violation	FCM	Yes	Yes	995	990.2		degF
Pause all furnace sequences, RH spray violation	FCM	Yes	No	5	23.6		klb/h
Pause all furnace sequences, RH outlet temp violation	FCM	Yes	No	975	995		degF
Inhibit convect zones, high opacity	SCE	No	No		19	100	percent
Ihibit convection zones from cleaning while clean	FCM	No	No				
Allow convection to clean while clean, high Dp	FCM	No	No		5.9	6	inH2O
Adjust convection uRatio biases, high Dp	FCM	No	No		5.9	7	inH2O
Request convection clean on time, high Dp	SootOpt	No	No		6	8	inH2O
Inhibit furnace zones from cleaning while clean	SootOpt	No	No				
Allow furnace zones to clean while clean, high RH sprays	SootOpt	No	No		23.6	40 klb/h	klb/h
Adjust furnace flux biases, high RH sprays	SootOpt	No	No		23.6	100	klb/h
Request furnace clean on time, high RH sprays	SootOpt	No	No		23.6	100	klb/h

DYNEGY

ProcessLink

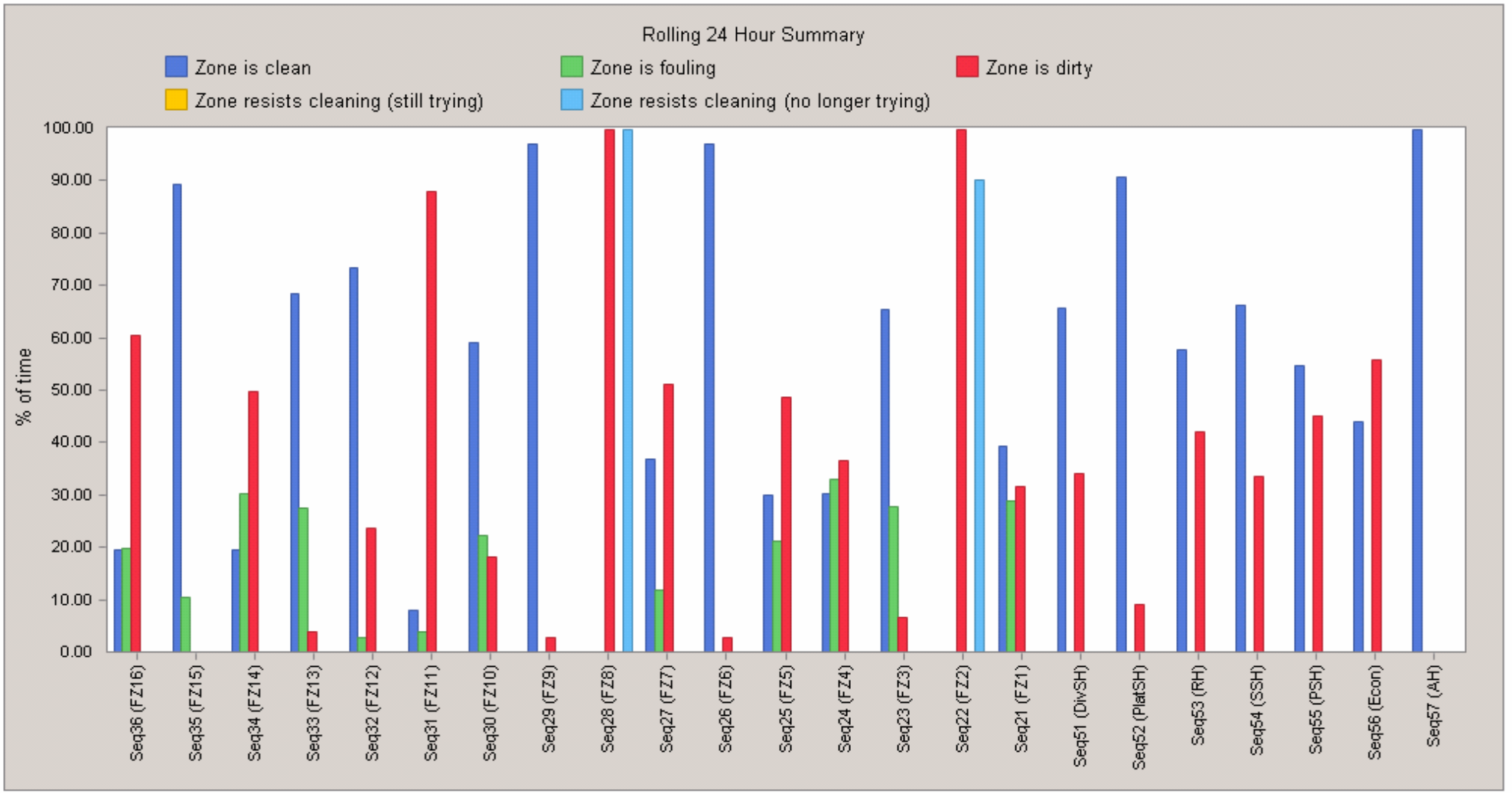
Session Documents Memory Help

Unit 3: SootOpt Analysis

1 day | 11/02/2006 05:11:05 PM

Standard | Demystifier | Trend | Model | Scatter | Surface | Sensitivity | Std Error | Custom

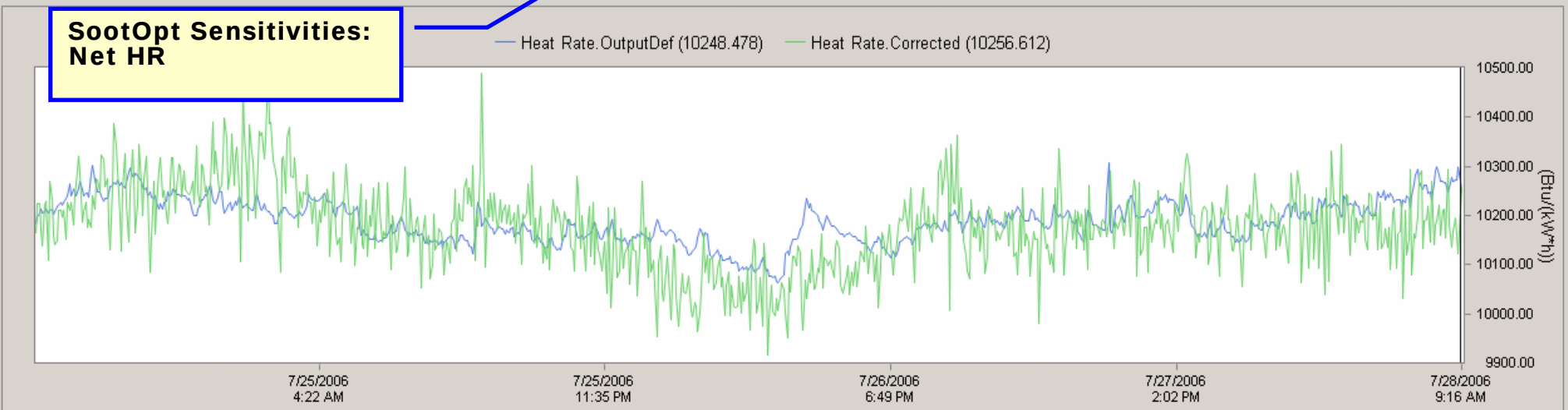
Activity/Status | Zone States | Boiler Map



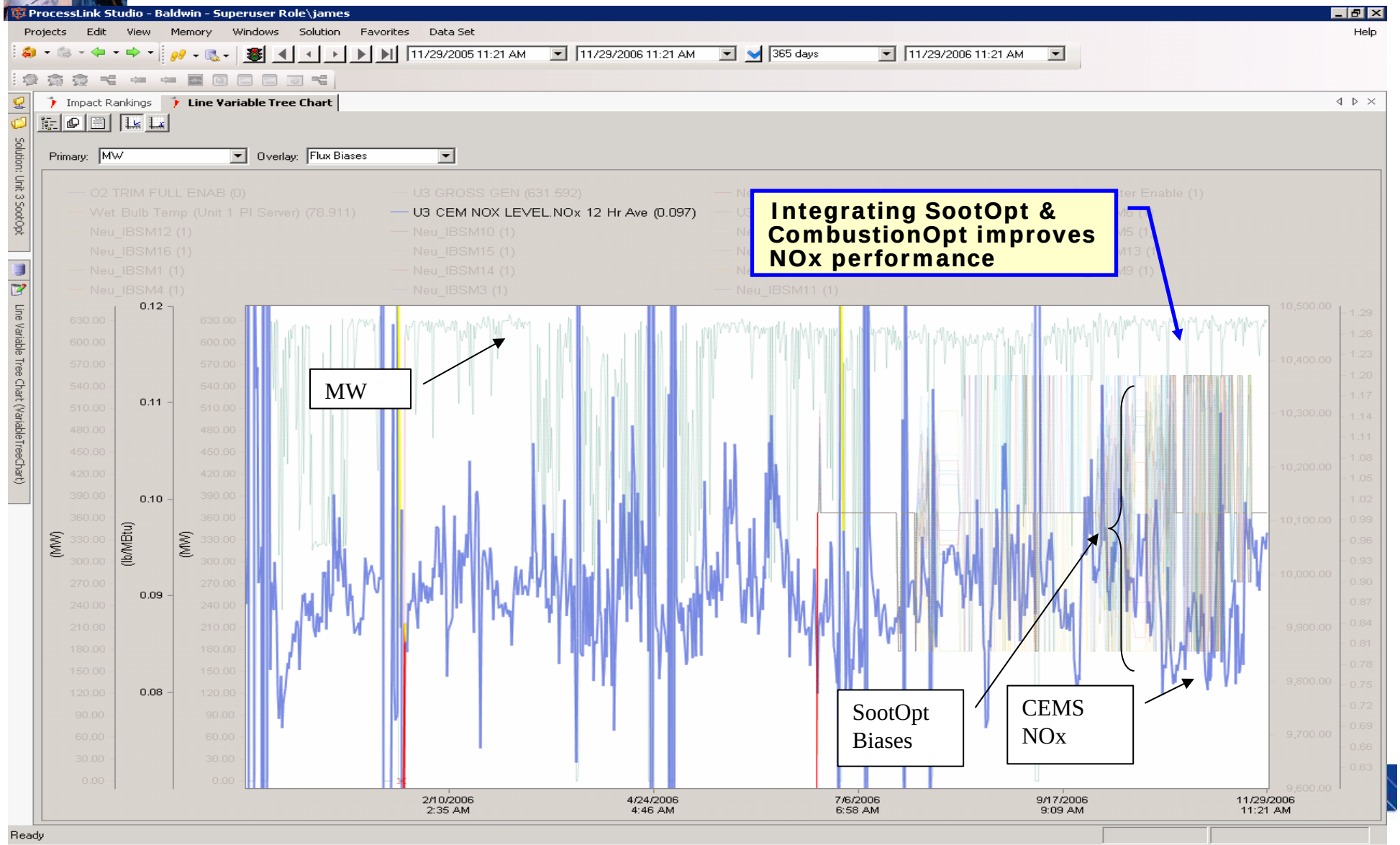
Ready

Modelled Function: Heat Rate ☑ All Inputs

SootOpt Sensitivities: Net HR



1 Year of Data (MW, NOx, SootOpt Biases)



NOx & HR vs MW (w/CombustionOpt + SootOpt)

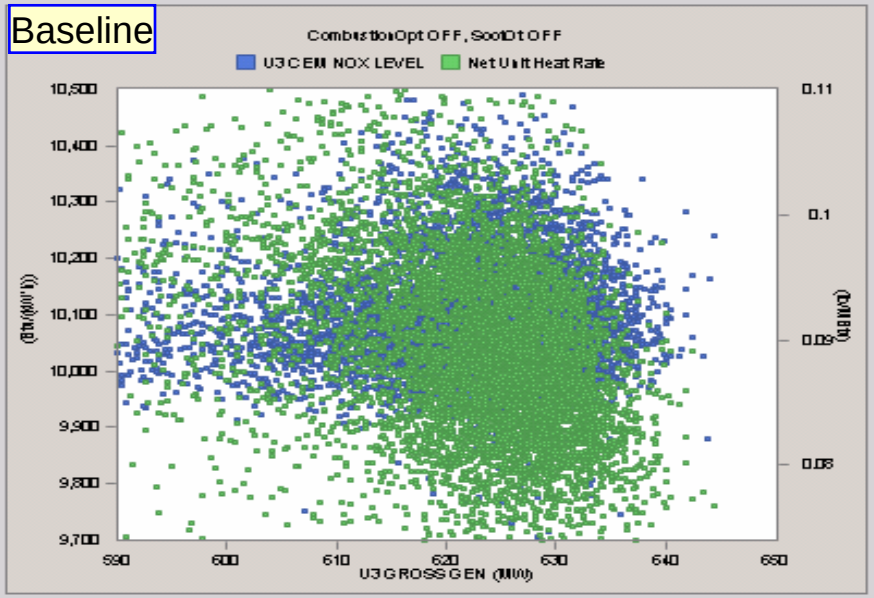
NOx = blue

HR = green

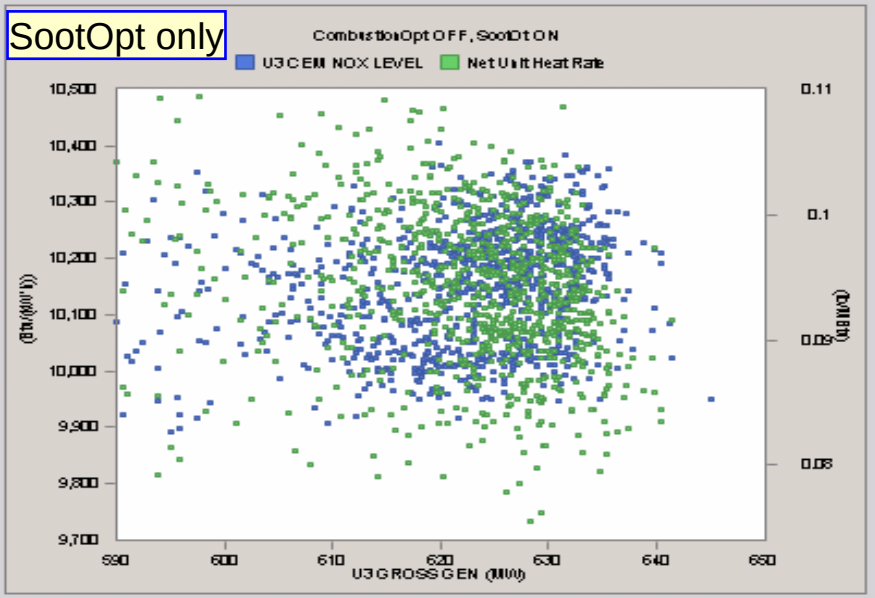
ON/OFF Data ...sis - complete

365 days | 01/03/2007 12:57:33 PM

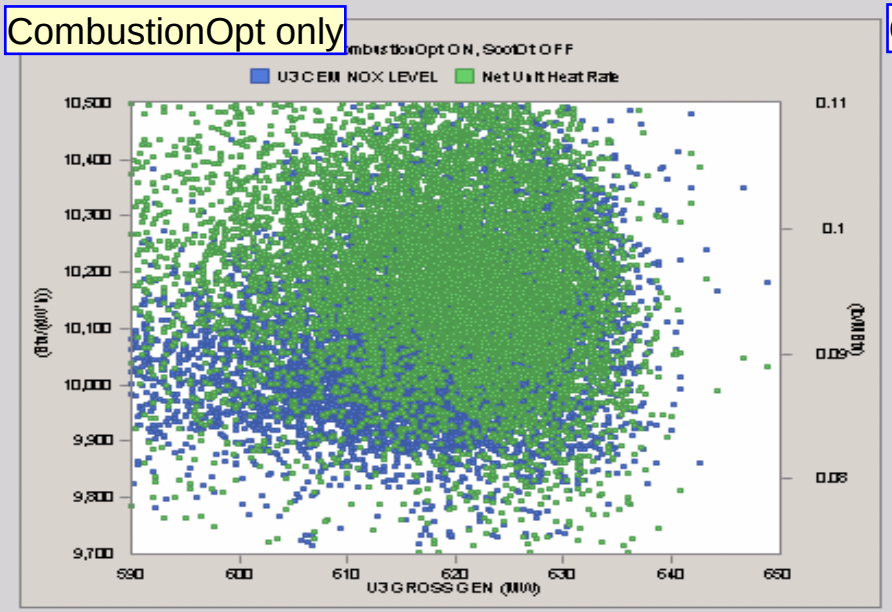
Baseline



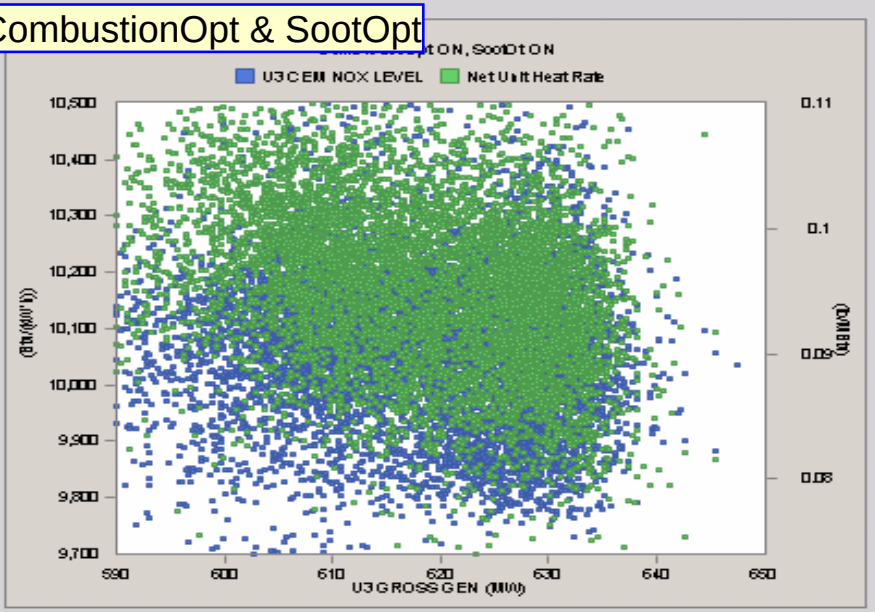
SootOpt only



CombustionOpt only



CombustionOpt & SootOpt



Session Documents Memory Help

Unit 3: SootOpt Analysis

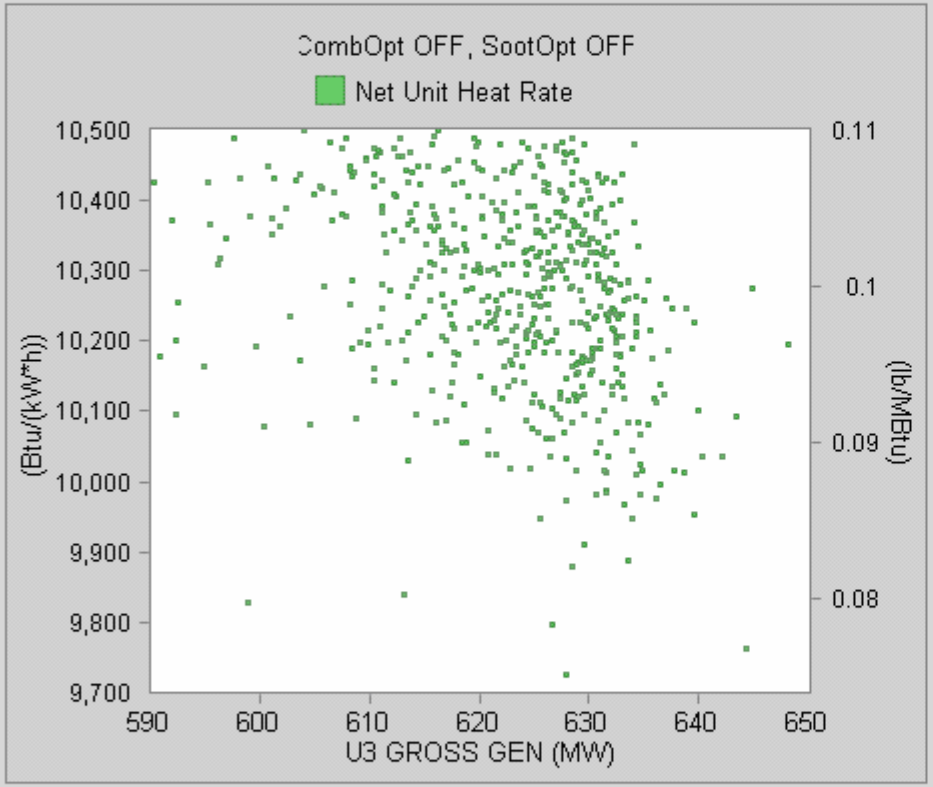
1 day | 01/24/2007 08:51:00 AM

Standard | ON/OFF | Demystifier | Trend | Model | Scatter | Surface | Sensitivity | Std Error | Custom

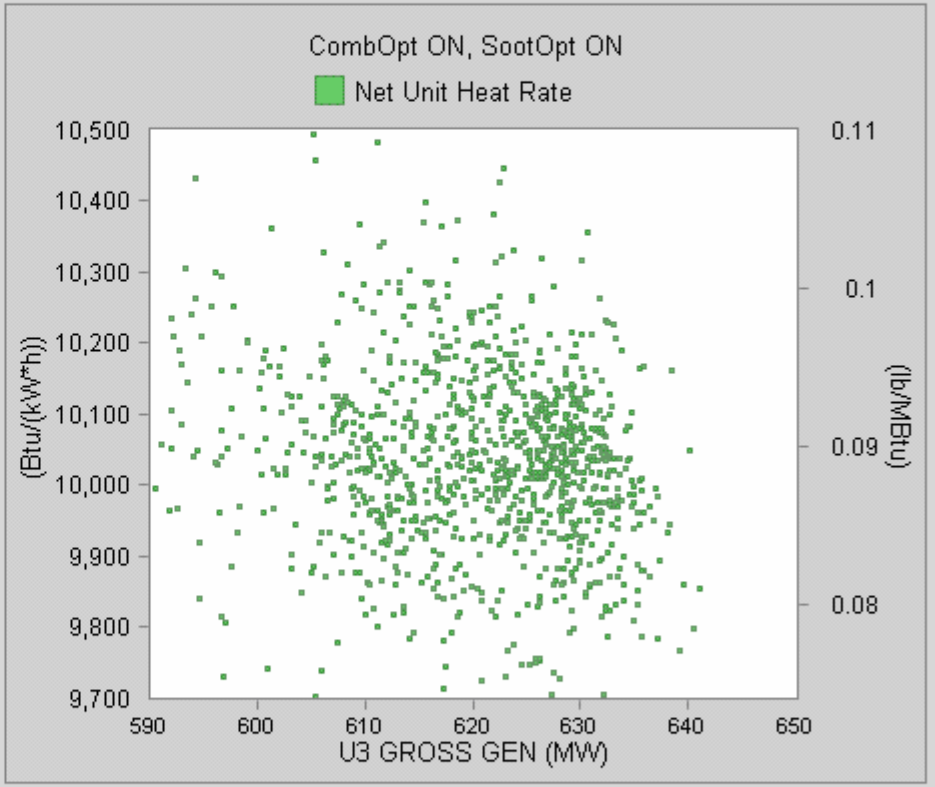
Scatter Plots (30days)

Comb OFF,Soot OFF | Comb ON, Soot ON | Comb OFF,Soot ON | Comb ON,Soot OFF

X-Axis: U3 GROSS GEN



X-Axis: U3 GROSS GEN



ProcessLink

Session Documents Memory Help

Unit 3: SootOpt Analysis

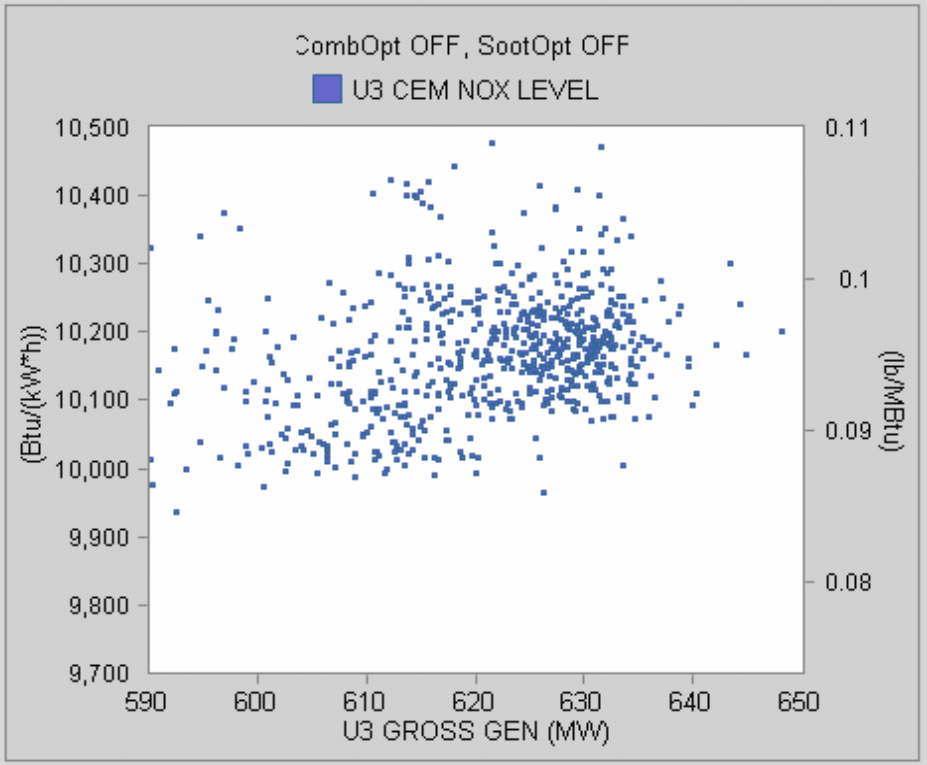
1 day | 01/24/2007 08:51:00 AM

Standard | ON/OFF | Demystifier | Trend | Model | Scatter | Surface | Sensitivity | Std Error | Custom

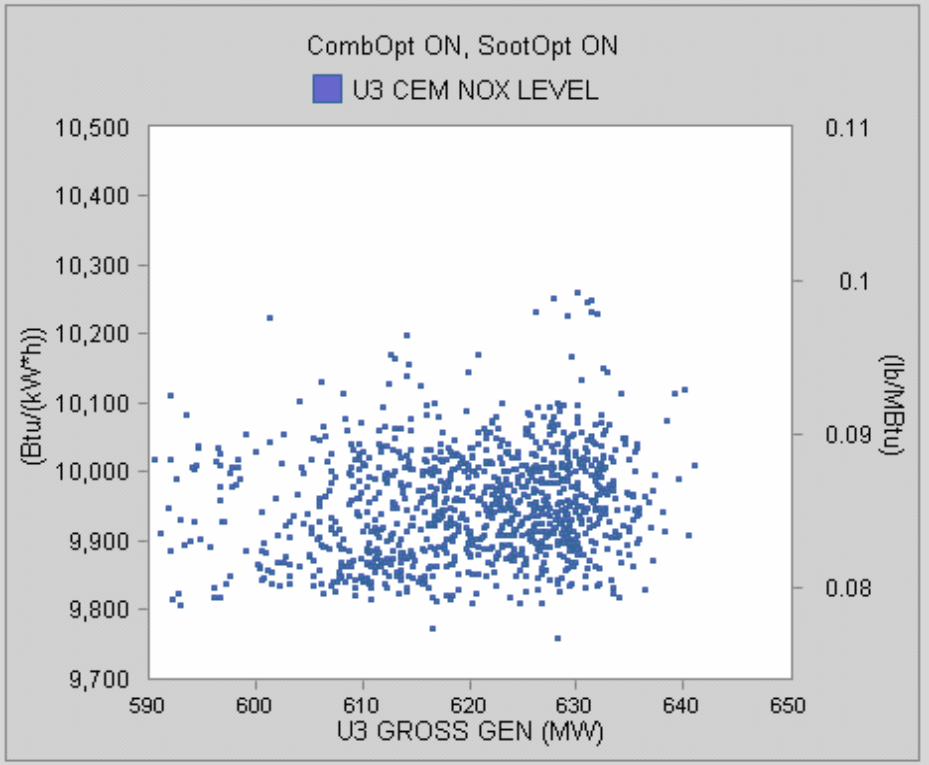
Scatter Plots (30days)

Comb OFF,Soot OFF | Comb ON, Soot ON | Comb OFF,Soot ON | Comb ON,Soot OFF

X-Axis: U3 GROSS GEN



X-Axis: U3 GROSS GEN



Ready

ProcessLink

Session Documents Memory Help

Unit 3: SootOpt Analysis

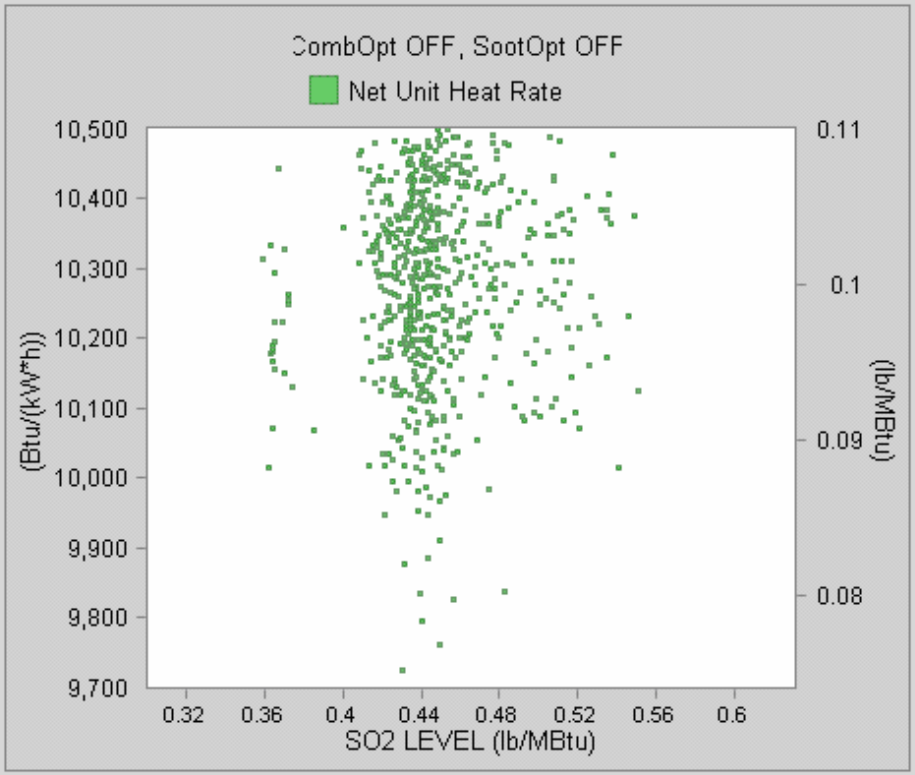
1 day | 01/24/2007 08:51:00 AM

Standard | ON/OFF | Demystifier | Trend | Model | Scatter | Surface | Sensitivity | Std Error | Custom

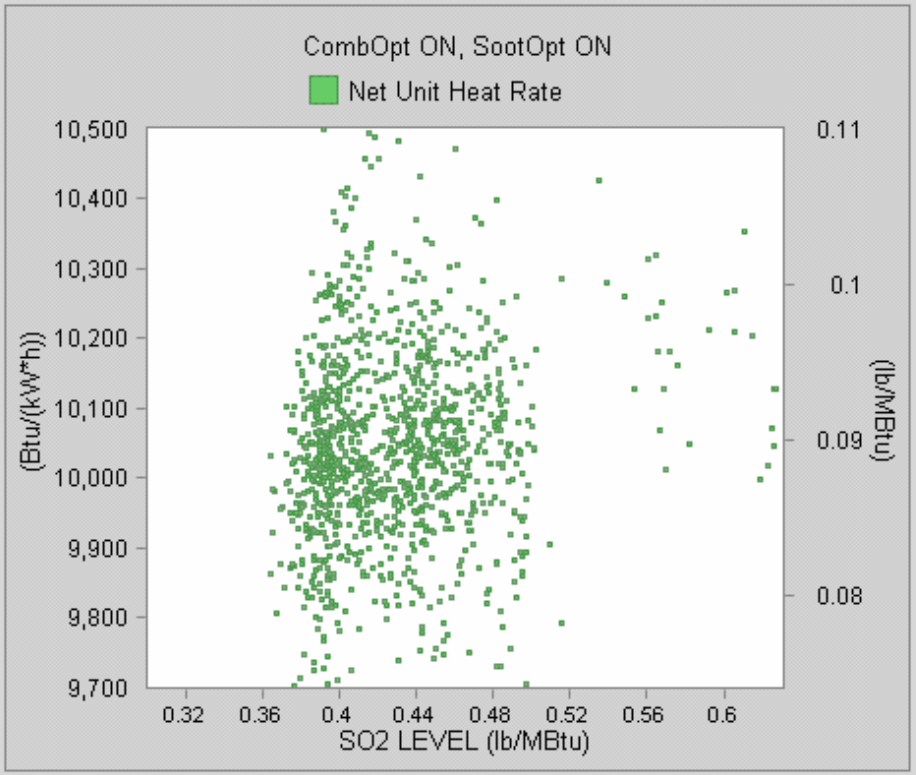
Scatter Plots (30days)

Comb OFF,Soot OFF | Comb ON, Soot ON | Comb OFF,Soot ON | Comb ON,Soot OFF

X-Axis: SO2 LEVEL



X-Axis: SO2 LEVEL



Ready

ProcessLink

Session Documents Memory Help

Unit 3: SootOpt Analysis

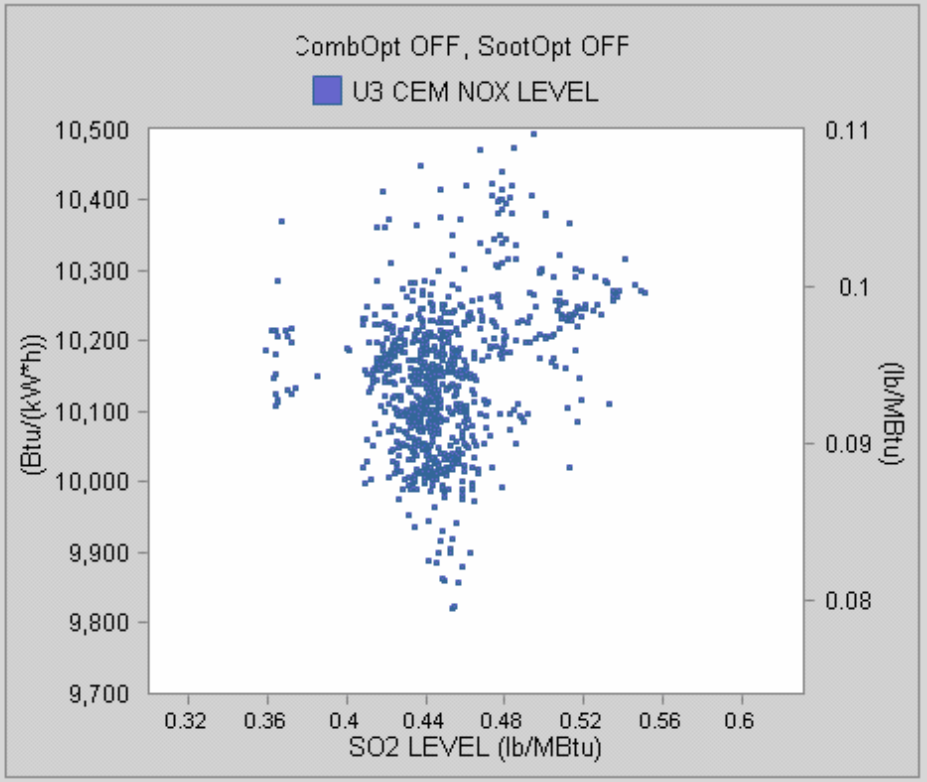
1 day | 01/24/2007 08:51:00 AM

Standard | ON/OFF | Demystifier | Trend | Model | Scatter | Surface | Sensitivity | Std Error | Custom

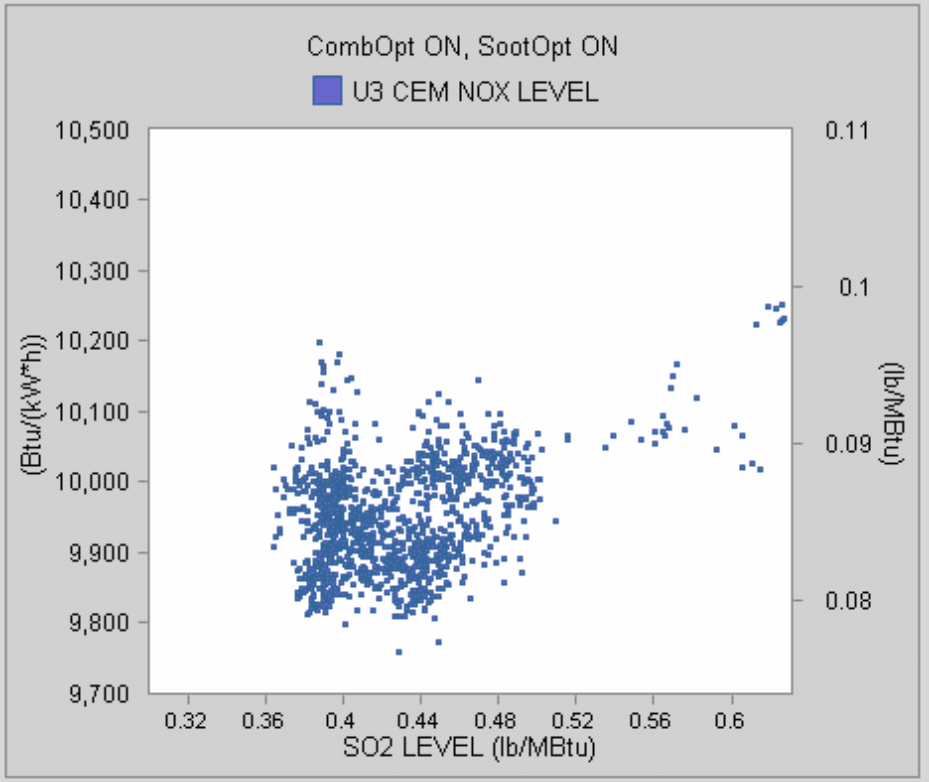
Scatter Plots (30days)

Comb OFF,Soot OFF | Comb ON, Soot ON | Comb OFF,Soot ON | Comb ON,Soot OFF

X-Axis: SO2 LEVEL



X-Axis: SO2 LEVEL



Ready

ProcessLink

Session Documents Memory Help

Unit 3: SootOpt Analysis

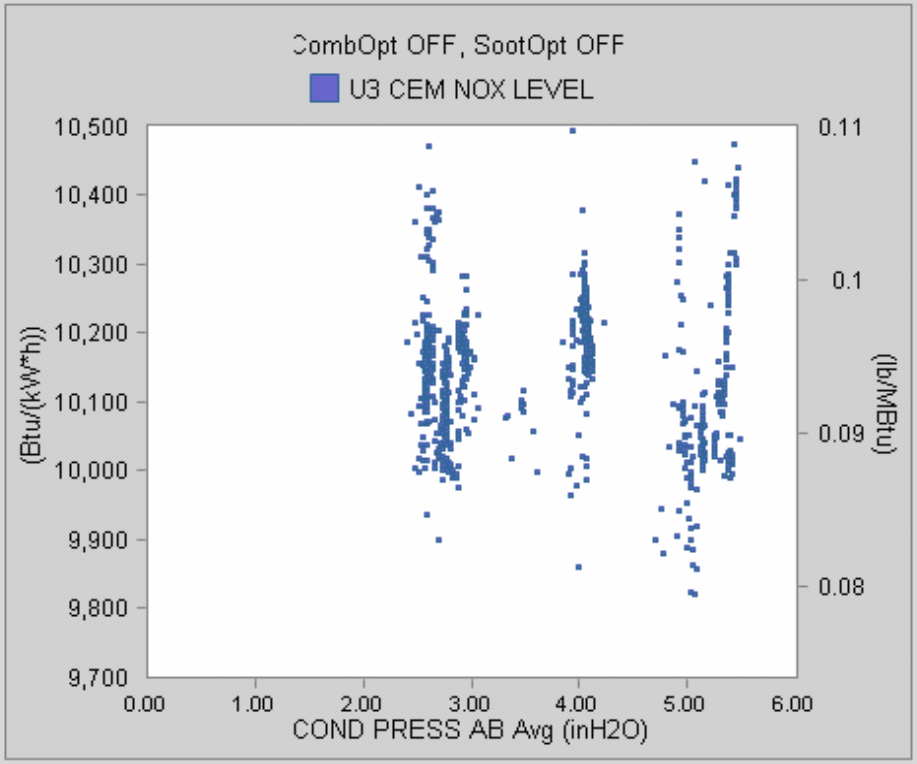
1 day | 01/24/2007 08:51:00 AM

Standard | ON/OFF | Demystifier | Trend | Model | Scatter | Surface | Sensitivity | Std Error | Custom

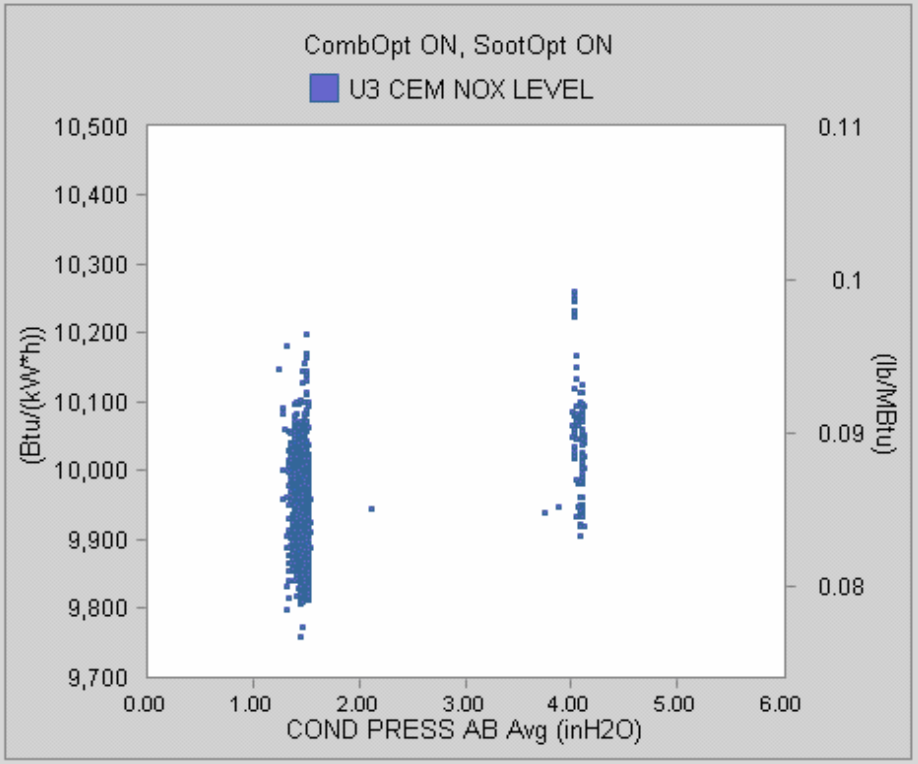
Scatter Plots (30days)

Comb OFF,Soot OFF | Comb ON, Soot ON | Comb OFF,Soot ON | Comb ON,Soot OFF

X-Axis: COND PRESS AB Avg



X-Axis: COND PRESS AB Avg



Ready

ProcessLink

Session Documents Memory Help

Unit 3: SootOpt Analysis

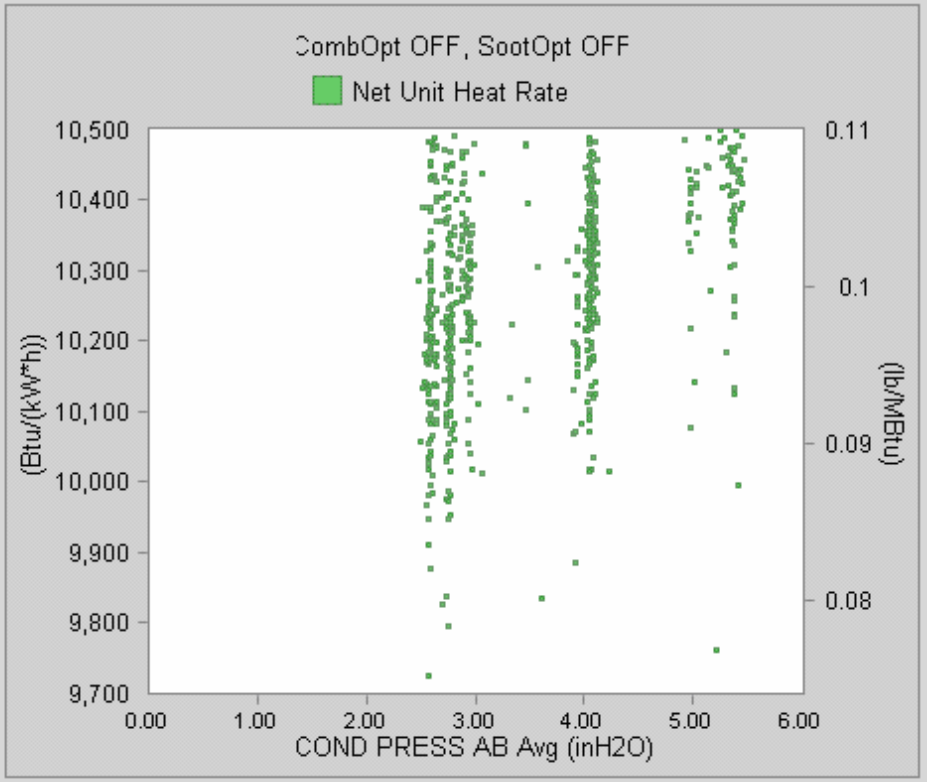
1 day | 01/24/2007 08:51:00 AM

Standard | ON/OFF | Demystifier | Trend | Model | Scatter | Surface | Sensitivity | Std Error | Custom

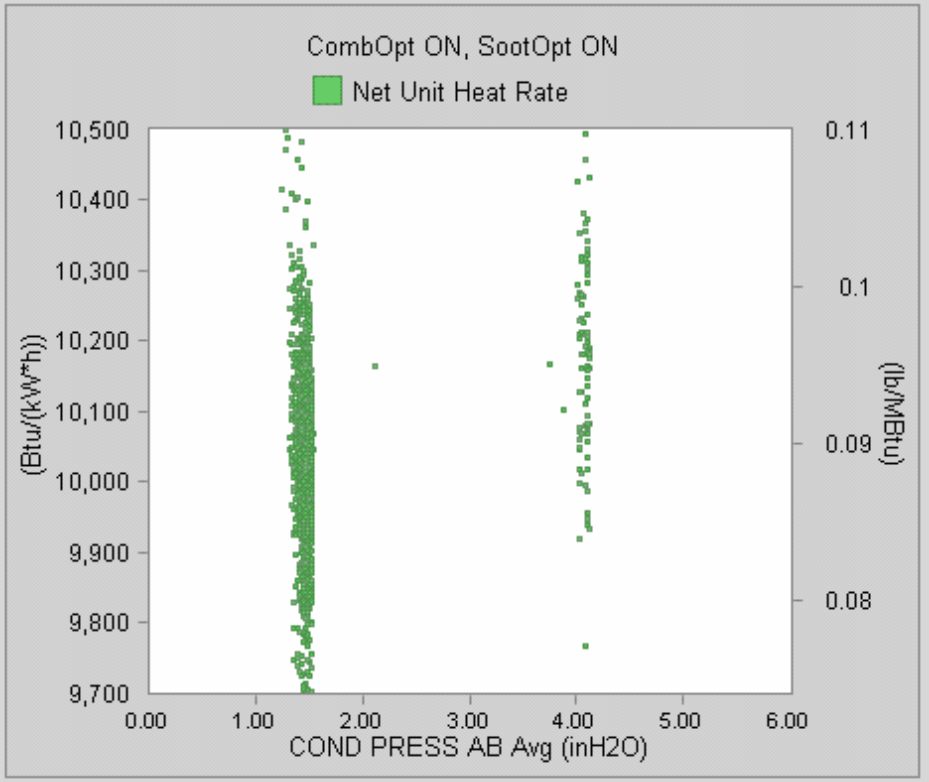
Scatter Plots (30days)

Comb OFF,Soot OFF | Comb ON, Soot ON | Comb OFF,Soot ON | Comb ON,Soot OFF

X-Axis: COND PRESS AB Avg

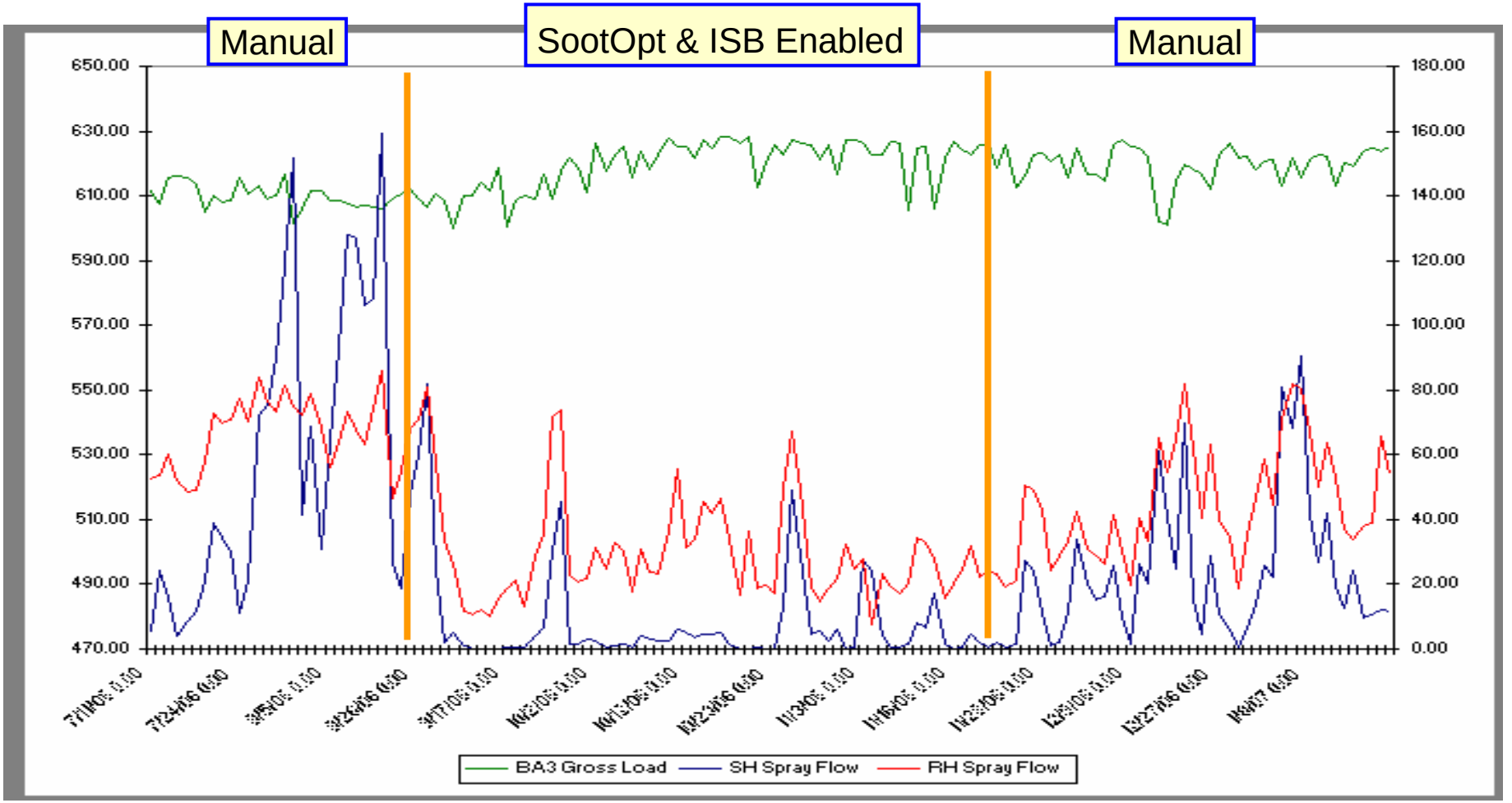


X-Axis: COND PRESS AB Avg



Ready

Average Daily Attemperation Spray Flows



DYNEGY

IK Activity Manual vs ISB/SootOpt

ProcessLink

Session Documents Memory Help

30 days 01/18/2007 03:47:38 PM

IK Ops, Yesterday (171)

Decreased sootblower activity when SootOpt turned back on

220.00 210.00 200.00 190.00 180.00 170.00 160.00 150.00 140.00 130.00 120.00 110.00 100.00 90.00 80.00 70.00 60.00 50.00 40.00 30.00 20.00 10.00 0.00

12/25/2006 2:35 PM | 12/31/2006 2:53 PM | 1/6/2007 3:10 PM | 1/12/2007 3:27 PM | 1/18/2007 3:45 PM

Ready

DYNEGY

SootOpt/ISB Results Thus Far

- Operating on Unit 3
  - Decreased sootblower operation count
  - Attemperation spray flows are controlled to less than 50 klbhr with SootOpt/ISB whereas before spray flows would at times be above 100 klbhr
  - Initially due to the split attemperation flow control (2 reheat controllers & 2 superheat controllers), steam temperatures would drop to 950F which could effect MW output. Recent changes have reduced that drop to 980F
  - Improvements in NOx rates have been seen when CombustionOpt and SootOpt are working together
- Being installed on Unit 2 in February 2007
  - Unique opportunity to quantify contributions of individual ISB control and instrumentation components

DYNEGY